Electrical modules	Name	What	Input	Output	Supplier	Part no.	Location	Notes
	T1	3 wire RTD			Omega	RTD-NPT-72-E	Top of top hat	TS-TE1 in the flow diagram
	T2	4 wire RTD			Omega	PR-21D-3-100-A-1/8-1500-M12-1	Bottom of top hat	TS-TE2 in the flow diagram
	T3	3 wire RTD			Omega	RTD-NPT-72-E	Top of water bath	TS-TE3 in the flow diagram
	T4	3 wire RTD			Omega	RTD-NPT-72-E	Middle of water bath	TS-TE4 in the flow diagram
	T5	3 wire RTD			Omega	RTD-NPT-72-E	Bottom of water bath	TS-TE5 in the flow diagram
	PT1	pressure transducer	9-30 VDC (<10 mA)	0-5 VDC	Omega	PX319-300A5V	Hydraulic cart pressure	
	PT2	pressure transducer	9-30 VDC (<10 mA)	0-5 VDC	Omega	PX319-300A5V	High pressure accumulator	
	PT3	pressure transducer	9-30 VDC (<10 mA)	0-5 VDC	Omega	PX319-300A5V	Low pressure accumulator	
	PT4	pressure transducer	10-30 VDC	0-5 VDC	Setra	225 G250 PAD 42BB1	Chamber plumbing	
	PT5	pressure transducer	9-30 VDC (<10 mA)	0-5 VDC	Omega	PX319-300A5V	Top hat	
	PT6	dytran fast pressure transducer	0-5 VDC	0-5 VDC	Dytran	2005V	Top hat	
	Dytran supply	Dytran current supply		0-5 VDC, 1/4 A	Dytran	4112V		
	EV1	solenoid valve	120 VAC, 10 W		Omega	SV131	Compression valve	
	EV2	miniature solenoid valve	12, 24 VDC, 12 W max		Parker	009-0172-900	High pressure tweak on hydraulic system	
	EV3	miniature solenoid valve	12, 24 VDC, 12 W max		Parker	009-0172-900	Low pressure tweak on hydraulic system	
	Pump	miniature piston pump	120 VAC, 40 W		Clark	ET-150	Pump from low pressure accumulator to high pressure accumulator	
	H1	50 ohm resistive heater	50 W, 1 A		Cryocon	4039-012	Heater inside top hat of bubble chamber	
	Lakeshore controller	Temperature controller for heater	120 VAC	50 W, 1 A	Lakeshore	DRC-93C		
	Heat sense box	cRIO AI 6	1 A	1 A, 1 V	Custom		On top of Lakeshore	
	DI1	Digital input 1	TTL		Kings	KC-79-67 QD	Low voltage box	
	DI2	Digital input 2	TTL		Kings	KC-79-67 QD	Low voltage box	
	DI3	Digital input 3	TTL		Kings	KC-79-67 QD	Low voltage box	
	DI4	Digital input 4	TTL		Kings	KC-79-67 QD	Low voltage box	
	DO1	Digital output 1		TTL	Kings	KC-79-67 QD	Low voltage box	
	DO2	Digital output 2		TTL	Kings	KC-79-67 QD	Low voltage box	
	Ac1	Acoustic transducer 1		0-5 V	IUSB		Attached to bubble chamber	
	Mightex	Mightex LED driver	120 VAC	24 V, 1 A DC, 3.	MIghtex	SLC SA02	Inside Mightex box	
	LEDs	Luxeon leds	up to 1.4 A		Luxeon	LXHL-LD3C	At chamber, next to bath	Typical 3 V drop across each
	24 V supply 1		120 VAC, 60 W	24 V, 2.5 A	Rhino	PSC-24-060	Inside HV box	
	24 V supply 2		120 VAC, 60 W	24 V, 2.5 A	Rhino	PSC-24-060	Inside HV box	
	12 V supply		120 VAC, 15 W	12 V, 1.25 A	Rhino	PSC-12-015	Inside HV box	
	Relay 1	Solid state relay	120 VAC relay		Opto	120D3	Inside HV box	
	Relay 2	Solid state relay	120 VAC relay		Opto	120D3	Inside HV box	
	Relay 3	Solid state relay	24 V relay		Opto	DC60S3	Inside HV box	
	Relay 4	Solid state relay	24 V relay		Opto	DC60S3	Inside HV box	
	cRIO module	Sensor and digital i/o controller	24 V, 20 W MAX		NI	NI cRIO-9074	Inside LV box	
		DIO 5 V TTL cRIO module	TTL	TTL	NI	NI 9403	Connected to cRIO	
		AO +- 10 V		+-10 V	NI	NI 9263	Connected to cRIO	
		AI +- 20 mA	+- 20 mA		NI	NI 9203	Connected to cRIO	
		AI Universal	up to 60 V or 25 mA		NI	NI 9219	Connected to cRIO	
		AO 20 mA		20 mA	NI	NI 9265	Connected to cRIO	
		AI +-10 V	+- 10 V		NI	NI 9201	Connected to cRIO	
		AI RTD	RTD signals		NI	NI 9217	Connected to cRIO	
		DIO 5 V TTL cRIO module	TTL	TTL	NI	NI 9403	Connected to cRIO	
Manual valves	Name	Location	Supplier	Part number				
	MV1	Line from cart to bubble chamber	McMaster	45395K121				
	MV2	Needle valve behind EV2	McMaster	7836K26	Ideal Valve	5-2-11		
	MV3	Needle valve behind EV3	McMaster	7836K26				
	MV4	Fill line for high pressure accumulator	McMaster	45395K121				
	MV5	Pump port for high pressure accumulator	McMaster	45395K121				
	MV6	Fill line for low pressure accumulator	McMaster	45395K121				
	MV7	Pump port for low pressure accumulator	McMaster	45395K121				
	MV8	Fitting at top of high pressure accumulator	Parker	AD016B25T9A1				
	MV9	Fitting at top of low pressure accumulator	Parker	AD007B25T9A1				
	MV10	Needle valve on fluid side, before PT4	Swagelok	SS-4MG-VCR-MH				
	MV11	Fill line of inner volume	Swagelok	6LVV-DPFR4-P				
	MV12	Bleed out valve for inner volume	Swagelok	6LVV-DPFR4-P				
	MV13	Inlet line from hydraulic cart	McMaster	45395K121				
	MV14	Pump out port of hydraulic system on bubble chamber	McMaster	45395K112				
	MV15	Valve for neslab return	Swagelok	SS-4P4T4				
Miscellaneous	F1	Filter on fill line of inner volume	Pall	GLFPF3000VMM4				
	Hydraulic hose	Connection between hydraulic line and chamber	Parker	540N-6				

Source	Destination	Line	Cable wire color	Connector pins	Box wire color	Input pins	Notes
T1 - temperature sensor at top of top hat	Low voltage box, cRIO RTD module	+Excitation	Red	A	Red	RTD 1	TS-TE1 in flow diagram
3 wire RTD		-Excitation	Black	B	Black	RTD 2	
Omega RTD-NPT-72-E		Common	Black	C	Black	RTD 3	
			none	D	none	none	
T2 - temperature sensor at bottom of top hat	Lakeshore Temperature Controller	Provided cable					TS-TE2 in flow diagram
4 wire RTD	Input A						
Omega PR-21D-3-100-A-1/8-1500-M12-1							
Lakeshore Temperature Controller	Low voltage box, cRIO AI module	Voltage Out		A	Black	AI 5	
7 pin output from back		Voltage In		B	White/Orange		
		10 mV/K analog out (not active)		C	Red		
		Gnd for analog out		D	Black	AI 9	
		Setpoint out		E	Green	AI 7	
		Gnd for Voltage Out and Setpoint out		F	Brown	AI 9	
		Optional shield		H	White/Blue		
Lakeshore Temperature Controller	50 Ohm heater, via “Sense/Heat” box	Out	Coax lead				Sense/Heat box contains a 1 ohm resistor to measure voltage across
Heater output		Return	Coax ground				The heater has an isolated ground, the 1 ohm resistor comes after the heater. The box is at the Lakeshore ground
Sense/Heat box	cRIO, Heater Input, AI 6	V+	Coax lead		Red	AI 6	
		V-	Coax ground		Black	AI 9	
T3 - temperature sensor at top of bath	Low voltage box, cRIO RTD module	+Excitation	Brown	1-A	Red	RTD 4	TS-TE3 in flow diagram
4 wire RTD		-Excitation	White	2-B	Black(Yellow tap	RTD 7	
Omega PR-21D-3-100-A-1/8-200-M12-1		+Signal	Blue	3-C	Black	RTD 6	
		-Signal	Black	4-D	White	RTD 5	
T4 - temperature sensor at mid bath	Low voltage box, cRIO RTD module	+Excitation	Red	A	Red	RTD 9	TS-TE4 in flow diagram
3 wire RTD		-Excitation	Black	B	Black	RTD 10	
Omega RTD-NPT-72-E		Common	Black	C	Black	RTD 11	
			none	D	none	none	
T5 - temperature sensor at bottom of bath	Low voltage box, cRIO RTD module	+Excitation	Brown	1-A	Red	RTD 4	TS-TE5 in flow diagram
3 wire RTD		-Excitation	White	2-B	Black(Yellow tap	RTD 7	
Omega PR-21D-3-100-A-1/8-200-M12-1		+Signal	Blue	3-C	Black	RTD 6	
		-Signal	Black	4-D	White	RTD 5	
PT1 - pressure at hydraulic system	Low voltage box, cRIO AI module	+Excitation	Red	A	Red	+12 V junction rail	
Omega PX319-300A5V		-Excitation	Green	B	Green	-12 V junction rail	-12 V junction rail is tied to AI 9 (common ground on AI module)
		Sgn	Black	C	Black	AI 0	
			none	D	none	none	
PT2 - high pressure accumulator	Low voltage box, cRIO AI module	+Excitation	Red	A	Red	+12 V junction rail	
Omega PX319-300A5V		-Excitation	Green	B	Green	-12 V junction rail	-12 V junction rail is tied to AI 9 (common ground on AI module)
		Sgn	Black	C	Black	AI 1	
			none	D	none	none	
PT3 - low pressure accumulator	Low voltage box, cRIO AI module	+Excitation	Red	A	Red	+12 V junction rail	
Omega PX319-300A5V		-Excitation	Green	B	Green	-12 V junction rail	-12 V junction rail is tied to AI 9 (common ground on AI module)
		Sgn	Black	C	Black	AI 2	
			none	D	none	none	
PT4 - bubble chamber pressure	Low voltage box, cRIO AI module	+Excitation	Red	A	Red	+12 V junction rail	
Setra 225 G250 PAD 42BB1		+Output	Black	B	White	AI 3	
		-Output	Green	C	Green	AI 9	
		-Excitation	White	D	Black	-12 V junction rail	-12 V junction rail is tied to AI 9 (common ground on AI module)
PT5 - top hat pressure	Low voltage box, cRIO AI module	+Excitation	Red	A	Red	+12 V junction rail	
Omega PX319-300A5V		-Excitation	White	B	Green	-12 V junction rail	-12 V junction rail is tied to AI 9 (common ground on AI module)
		Sgn	Green	C	Black	AI 4	
			none	D	none	none	
PT6 - Dytran fast pressure transducer	Dytran Current source	Provided cable					
Dytran 2005V							
Mightex box - trigger	Low voltage box, cRIO DIO module	+Cam 0	Red	A - A	Red	DI 0	
		-Cam 0	Orange	B - B	Orange	DI 9 (cmn gnd)	
		+Cam 1	Black	H - C	Green	DI 1	
		-Cam 1	Brown	J - D	Black	DI 10 (cmn gnd)	
Mightex box - LED driver	LED array	+LED 0	Brown	A		LED 0 +	
		- LED0	Red	B		LED 0 -	
		+LED 1	Black	H		LED 1+	
		-LED 1	Orange	J		LED 1-	
LED array	From Mightex box						
Cam0	From Mightex via RJ45 cable						
Cam1	From Mightex via RJ45 cable						
Acoustic transducer	Acoustic breakout box	Vcc	Red	A	Green	Internal 3	Red
		Vee	Green	C	Red	Internal 4	White
		Vgnd	Black	B	Black	Internal 5	Black
		Sgn+	Blue	F	Black	Internal 1	Green
		Sgn-	White	E	White	Internal 2	Orange
Trigger signals from PC and Labview	DI 1-4, to cRIO DIO module	+TTL			Red	DI 16-19	
	BNC inputs	Gnd			Black	DI cmn gnd	
	DO 1-4, to cRIO DIO module	+TTL			Red	DO 24-27	
	BNC outputs	Gnd			Black	DO cmn gnd	
EV1 - compression valve	High voltage box	+120 AC	Black	Conduit		+120 AC junction rail	Junction rail powered by relay 2, which is activated by DO 0 of cRIO
		Neutral	Black			Gnd junction rail	
EV2 - high pressure tweak	High voltage box	+24 V	Yellow	Conduit		+24 V junction rail	Junction rail powered by relay 3, which is activated by D0 1 of cRIO
Parker 009-0172-900		-24 V	Yellow			-24 V junction rail	
EV3 - low pressure tweak	High voltage box	+24 V	Yellow	Conduit		+24 V junction rail	Junction rail powered by relay 4, which is activated by D0 2 of cRIO
Parker 009-0172-900		-24 V	Yellow			-24 V junction rail	
Pump	High voltage box	+120 AC	Black	Conduit		120 VAC junction rail	Junction rail powered by relay 1, which is activated by D0 3 of cRIO
Clark ET-150 pump		Neutral	Gray			Neutral junction rail	
		Gnd	Green			Gnd junction rail	
High voltage box	Low voltage box	+24 V	Red (Yellow tape)	Conduit		cRIO +24 input	
Power and relay lines to control system	Voltage to cRIO, pressure transducers	-24 V	Black (Yellow tape)			cRIO -24 input	
	Relay lines to cRIO DIO module	+12 V	Red (Blue tape)			+12 V junction rail	power for pressure transducers
		-12 V	Black (Blue tape)			-12 V junction rail	
		Relay 1	White/Brown			DO 3 (Pin 4)	
		Relay 2	White/Yellow			DO 0 (Pin 1)	
		Relay 3	White/Orange			DO 1 (Pin 2)	
		Relay 4	White/Blue			DO 2 (Pin 3)	
		Relay Gnd	White/Gray			DO 9 (Pin 10)	
AC Power supply attached to high voltage bo	High voltage box	+120 AC	Black	Conduit		120 VAC junction rail	Provides power for most of system
		Neutral	Gray			Neutral junction rail	
		Gnd	Green			Gnd junction rail	

	Old T3							
	Low voltage bo	+Excitation	Red	A	Red	RTD 5		
		-Excitation	Black	B	Black	RTD 6		
		Common	Black	C	Black	RTD 7		
			none	D	none	none		
	Old T5							
	T5 - temperatur	Low voltage bo	+Excitation	Red	A	Red	RTD 13	TS-TE5 in flow c
	3 wire RTD		-Excitation	Black	B	Black	RTD 14	
	Omega PR-21D	-3-100-A-1/8-2(	Common	Black	C	Black	RTD 15	
				none	D	none	none	